

Obstacle Management in VANET using Game Theory and Fuzzy Logic Control

Yousaf Saeed¹, Suleman Aziz Lodhi², Khalil Ahmed²

¹National College of Business Administration and Economics (NCBA&E), Lahore, Pakistan

Email: usafonline.email@gmail.com

²National College of Business Administration and Economics (NCBA&E), Lahore, Pakistan

Email: sulemanlodhi@yahoo.com

³National College of Business Administration and Economics (NCBA&E), Lahore, Pakistan

Email: marsnfire@yahoo.co.uk

Abstract—Mountainous roads where probability of land sliding exists, causes hurdles not only in the traffic flow but generate various traffic problems in the form of congestion, high accidents rate and wastage of time. The purpose of this paper is to minimize traffic congestion and wait time of the vehicles. Obstacle management is analyzed in Vehicular Adhoc Network and a mechanism is devised by using a cooperative game approach. Conflict between vehicles has been taken into consideration on one of the roads of mountainous area and two vehicles are considered to play the game. Possible actions, information set and strategies have been defined and payoffs are calculated. Finally, the outcome is achieved in the form of minimum time required for smooth flushing of the vehicles while fuzzy logic control has been used for simulation. It is found that by applying game theory in VANETs and fuzzy logic control for simulation, results can be achieved quite well in the form of minimizing traffic congestion and reduced wait time. The approach makes the traffic regularized not only in the mountainous areas but in urban and rural areas as well upon facing road hurdles. The involvement of Game Theory in VANETs makes it very useful approach in dealing with obstacle management.

Index Terms—VANET, Cooperative Game, GIS, Obstacle Management, Congestion, Fuzzy

I. INTRODUCTION

Land sliding is actually the downward sliding of mud, sand, rocks or debris and happens when the stability of slope changes from stable to unstable. It depends on a variety of factors that include deforestation, earthquakes, volcanic eruptions, heavy rains, blasting, vibrations caused by machinery, traffic or constructions, storms and human modifications. It is a global problem in the mountainous regions that causes destruction not only to humans but to the environment as well [1]. A major problem in tackling land sliding is due to its unpredictable nature. It is caused due to human intervention and natural influences [2].

As a safety measure, location should be known before traveling, the driver of the vehicle has to be alert at all times and sleep must be avoided, travelling in heavy rains or storms need to be avoided as well, a trickle of falling mud or rock on a road is a sign that a larger landslide might occur, making sound or vehicle horn must be avoided as sound waves could be a trigger, travelling during night time could be risky and

one should not stay in such area as moving away from such area must be driver's primary priority.

Driving in mountainous areas means constantly changing location, therefore, location information need to be known at a constant rate. Vehicular Adhoc Network also called VANET [3], play a key role in this aspect of information sharing [4][5]. Things get much better when vehicles convey timely information to one another and in this way a chain of interconnected vehicles forms. However, there are certain scenarios when active strategies between vehicles are required for information sharing. One such scenario is post land slide effect i.e. when land sliding has occurred on one of the road lanes and vehicles has to pass avoiding congested traffic. Hence, a co-operative game is used as a strategic game approach [6][7]. In Fig. 1, occurrence of landslide on one of the roads in mountainous region of Pakistan has been shown.

Looking at the rest of the paper, Section II is about the how a scenario is identified as a game in game theory. Section III depicts the structure of the game. Section IV describes the game methodology in which a framework is proposed. Section V elaborates the occurrence of time delay during the game play and payoff table is explained. In Section VI, simulation has been done with MATLAB and the game results are obtained.



Figure 1. Occurrence of landslide on a road connecting Kaghan and Naran areas of Pakistan

II. THE GAME

We consider that landslide has already occurred on a

mountainous road having two-way traffic with a standard road width. When landslide occurs and traffic stops on both the ends of the blockage, Vehicular Adhoc Networks facilitates a great deal. This means vehicles start communicating with each other and sends updates regarding the road blockage to the following vehicles. The oncoming vehicles thus know about the location and nature of the problem and as a result, vehicles can take precautionary measures. Being part of VANET [8], the bulldozer makes its way from its position to clear the obstacle in shorter period of time. Certain points must be defined on the road where bulldozers have to be on standby. These specific points must be at a distance of 1 km in a zigzag manner as shown in Fig. 2.

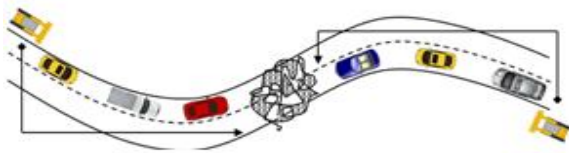


Figure 2. Specific road points for bulldozers

This enables easy access to the desired obstruction by the bulldozers when landslide occurs as traffic flushes from one end of the road from both sides of the land slide. Moreover, the vehicles on such road have to keep a distance of 5m for safety purposes, as on a normal road this safety distance is 2m when the weather is dry, 4m during rain and 6m during snow. On mountain roads when such vehicle distances are followed, it provides safety to a great deal.

III. GAME STRUCTURE

Players are defined as Vehicle A and Vehicle B. Regarding *Actions* of the vehicles, Player 1 has two options it can either maintain its speed and do not offer the gap (Not cooperate) to Player 2 or it can reduce its speed, stops and offer the gap (cooperation) to Player 2. On the other hand, Player 2 has certain options that it can either maintain its speed and do not cooperate, or it can reduce its speed and accept the gap offered by Player 1, or it can either reject the offered gap and do not cooperate. Both the players must have certain *information* of one another. They must know the time and location on real time basis, actions of one another and strategies and payoff functions.

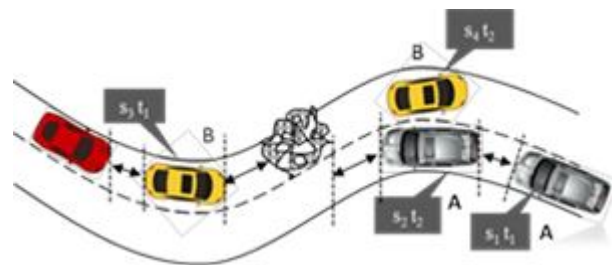
When *Strategies* are concerned, Player 1 has to reduce its speed and stop (cooperating) in order to offer the gap for Player 2. If Player 1 does not reduce its speed to stop, it will not cooperate. Similarly, Player 2 has to accept the offered gap (cooperating) in order to successfully get on the other side of the obstacle. If Player 2 does not accept the gap offered, it will not cooperate too. *Payoff* is the time delay caused by the actions of both the players while *Outcome* is the minimum delay for each of the two players. The *Equilibrium* is in the form of best and worst outcomes in the form of cooperate and not cooperate.

IV. METHODOLOGY

By considering the first two vehicles A and B as players

for a game, we consider that on both sides of the obstacle, these two vehicles are first in their queues. All the other vehicles on road depend on the strategy of these two vehicles to minimize the congestion. When the two vehicles pass the obstruction successfully, the vehicle next to them then serve as game players. In Fig. 3, the road is partly cleared for the traffic such that only one vehicle can pass the obstacle at a time due to reduced road width. Hence, a game approach is required.

Vehicle A has the option to stop and let vehicle B to pass by or it can go straight ahead with the same speed. On the other hand, vehicle B has the option to accept the gap offered by vehicle A or it can move with the same speed which might be dangerous or it can stop for longer period of time experiencing longer delay. However, in such strategy development, Global Positioning System (GPS) is an important aspect in vehicles in which information regarding location and position of a vehicle is known to other vehicles [9][10]. In order to regularize the traffic, certain rules need to be followed in which inter-vehicular distance should be 5 meters and car-to-obstacle distance should be 15 meters for safety



reasons. We consider that the width of obstacle is 15 meters. Looking at Fig. 3, time and distance of the two vehicles are shown in the form of t and s respectively.

For a successful game play, it is important that vehicles must have complete set of information. The proposed framework as shown in Fig.4, works in a proper manner. Control Unit of a vehicle gathers geographical information from the Geographic Information System (GIS) module and at the same time Global Positioning System (GPS) data of other vehicles are gathered as well. Having these information sets, a vehicle is notified in the form of Voice Recognition to go or to stop in a game play. This information is broadcasted to other vehicles in the queue using clustered approach and hence further congestion is avoided.

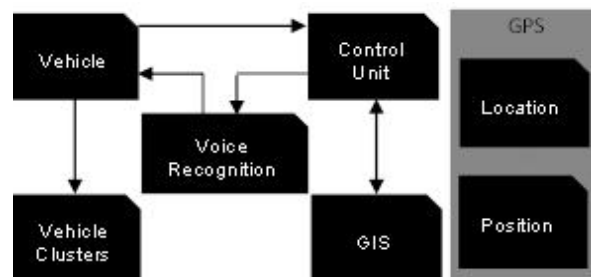


Figure 4. Framework of vehicle communication system in mountainous regions

V. TIME DELAY CALCULATION

When congestion is concerned, time is an important factor to be considered among vehicles. In case of Vehicle A and Vehicle B, adopting cooperative strategy consumes some amount of time but in this way maximum time wastage is avoided. Fig.5 shows the regularization of traffic flow with minimum delay when an obstacle exists on one of the road lanes.

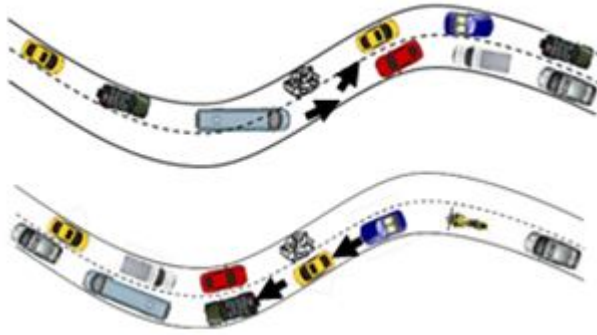


Figure 5. Timely flow of traffic in a successful gameplay

In Fig. 6, the straight line going up shows non-stop trajectory and the curve line shows the deceleration of speed and stopping for Vehicle A. Similarly, for Vehicle B, the straight line going up shows non-stop trajectory and the curve line going up lately is the deceleration of vehicle and maintain its speed again. The third curve is the stopping of vehicle. The following calculation shows time delay for both the players. Similarly, in Fig. 7, the straight line going up shows the non-stop trajectory of the vehicle without any delay. The second line that is slightly curved and going up again shows that the vehicle experienced some delay. The third line shows that the vehicle experienced delay which ultimately caused the vehicle to stop.

A. Considering Player 1 (Vehicle A)

Actual Time, $T = 16$ sec.

[Offer the Gap / Cooperation]

Stopping Time = Actual Time – (Deceleration Time + Stopping Time)

$$= 16 - (9+3) = 16 - 12 = 4 \text{ sec.}$$

[Do Not Offer / Not Cooperate]

Non-Stop Time = Actual Time – Actual Time

$$= 16 - 16 = 0 \text{ sec.}$$

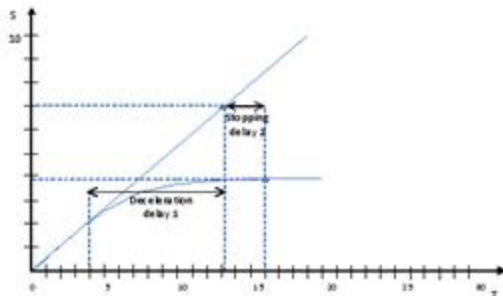


Figure 6. Time delay for vehicle A

B. Considering Player 2 (Vehicle B)

Actual Time, $T = 19$ sec.

[Accept the Gap / Cooperation]

Gap Acceptance Time = Actual Time – (Deceleration Time + Acceleration Time)

$$= 19 - (8+6) = 5 \text{ sec.}$$

[Do Not Accept / Not Cooperate]

Gap Rejection Time = Actual Time – (Deceleration Time + Stopping Time)

$$= 19 - (8+8) = 19 - 16 = 3 \text{ sec.}$$

[Do Not Stop / Not Cooperate]

Non-Stop Time = Actual Time – Actual Time

$$= 19 - 19 = 0 \text{ sec.}$$

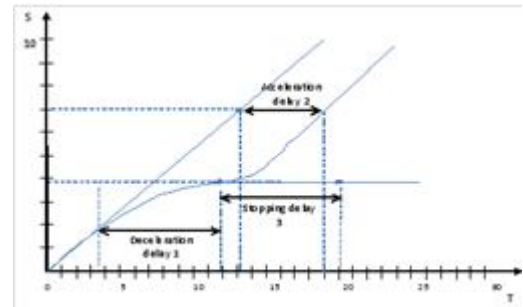


Figure 7. Time delay for vehicle B

The payoff table specifies that time is consumed by the cooperation of both the vehicles but this is an ideal situation in which traffic congestion reduces. If one of the vehicles cooperates and the other does not i.e. Vehicle A cooperates and Vehicle B does not, the delay time for Vehicle B is less than Vehicle A. When vehicle A is not cooperating and Vehicle B cooperates, not cooperating does not cost any delay, however, time is consumed. There are situations in which both the vehicles does not cooperate and be in a rush, then no delay will be there but this will be the worst scenario which will lead to disaster in the form of accident or collision and causes safety risk. All such figures are shown in Table I.

TABLE I. PAYOFF TABLE FOR THE GAME

		Player 2	
Player 1		Cooperate <i>Accept the gap</i>	Not Cooperate <i>Reject the gap</i>
	Cooperate <i>Offer the gap</i>	4, 5	4, 3
	Not Cooperate <i>Do not offer</i>	0, 5	0, 0

VI. SIMULATION

The purpose of simulation is to formulate a scheme through which traffic congestion is minimized. MATLAB is used for simulation and the results are achieved. Distance and speed of a vehicle are considered as inputs and on the basis of that minimum wait time for a vehicle is attained. This wait time is an ideal time in which the traffic flushes and shown in Fig. 8.

Membership functions are created for each of the two inputs and single output in the form of time. For distance, the

membership functions are given in the Fig. 9.

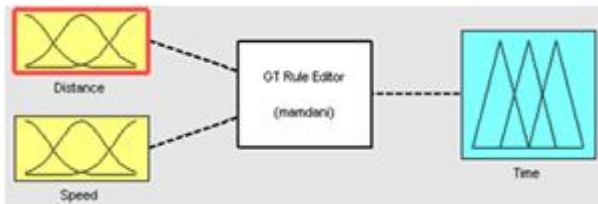


Figure 8. Input and output variables for vehicle

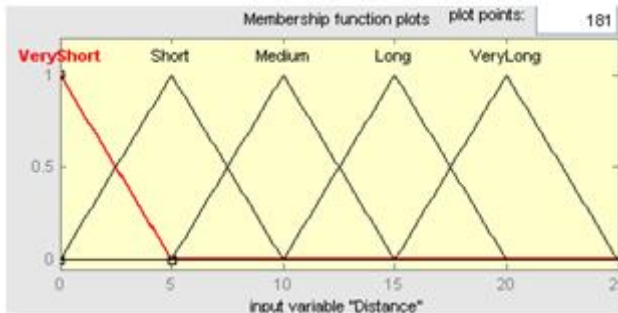


Figure 9. Membership functions for distance

Rules are created and shown in Fig. 10 which means if inter-vehicle distance is kept 5 meters and speed is kept at 20 km/h, the time delay will be of 15 seconds.

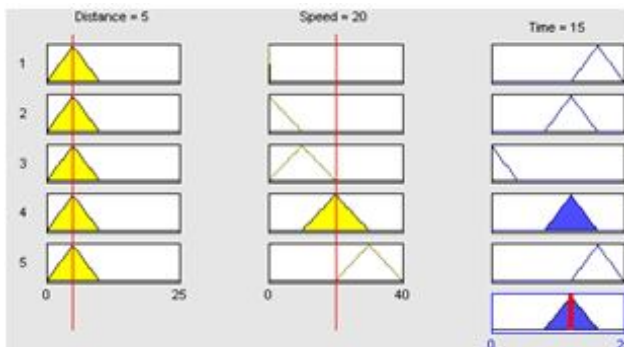


Figure 10. Rule viewer after defining rules

Finally, results are obtained in the form of graphs. In Fig. 11, the relation between time and distance is shown that if distance is kept 5 meters, overall 15 seconds time delay is experienced and then things are back to normal again. In Fig. 12, relation between time and speed is shown in which uniform time is achieved for having certain speed. In Fig. 13, three-dimensional relation between distance, speed and time are shown.

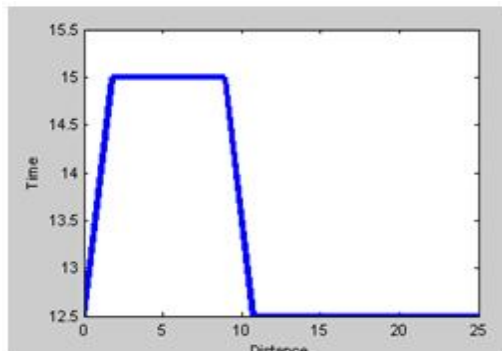


Figure 11. Relation between distance and time

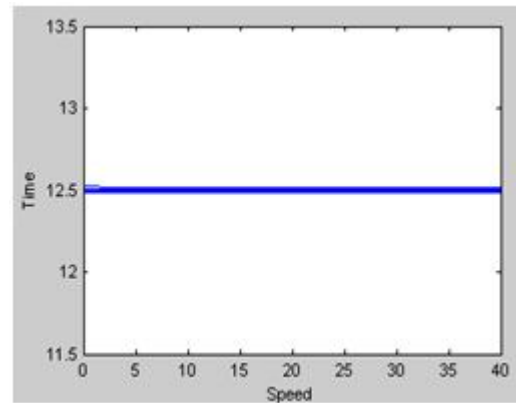


Figure 12. Relation between speed and time

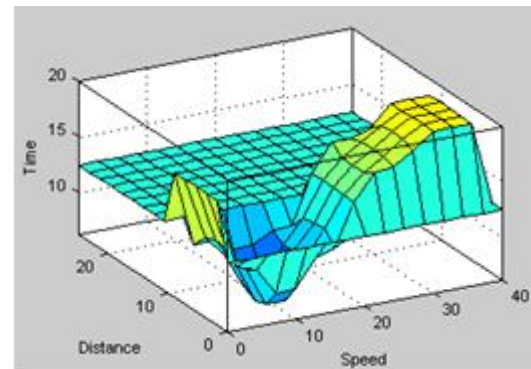


Figure 13. Three-dimensional relation between time, distance and speed

CONCLUSIONS

It is concluded that after the occurrence of landslides on mountainous roads, traffic congestion can be reduced in the form of minimized traffic delay by using game theory approach i.e. cooperative strategy along with VANET. Distance between the vehicles and speed of vehicles are important factors for the reduction of time delay, and using MATLAB as a simulation tool depicts such information in the form of generated results. This mechanism is not only suitable for public vehicles but for emergency vehicles like ambulance, police, and fire brigades. In order to achieve efficient results, following the traffic standards is an important aspect.

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